SF84.86
.U8
U5
1964

INTERMOUNTAIN STATION
Central Reference File
No. 9.41

1964
ANNUAL PROGRESS REPORT
RANGE REVEGETATION INVESTIGATIONS

FORAGE & RANGE BRANCH
CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

in cooperation with

UTAH AGRICULTURAL EXPERIMENT STATION
and
INTERMOUNTAIN FOREST
AND RANGE EXPERIMENT STATION

by

A. T. BLEAK, RANGE CONSERVATIONIST
LOGAN, UTAH

Copy Number 4

LIBRARY FILE COPY

1964

ANNUAL PROGRESS REPORT

RANGE REVEGETATION INVESTIGATIONS

FORAGE & RANGE BRANCH
CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

in cooperation with

UTAH AGRICULTURAL EXPERIMENT STATION

and

INTERMOUNTAIN FOREST
AND RANGE EXPERIMENT STATION

by

A. T. BLEAK
RANGE CONSERVATIONIST
LOGAN, UTAH

Copy Number

4

ACKNOWLEDGEMENT

Work covered in this report is cooperative among the following agencies:

Bureau of Land Management

Forest Service, Region 4

Intermountain Forest and Range Experiment Station

Soil Conservation Service

Utah State University

Appreciation is expressed to all personnel who assisted in laboratory or field work, reviewed study plans or manuscripts, and for their many helpful suggestions. Special thanks are due to the Utah State University and the Intermountain Forest and Range Experiment Station and Forest Service, Region 4, for providing office and storage space and other services.

NOT FOR PUBLICATION- This is a progress report of cooperative investigations containing data, the interpretation of which may be modified with additional experimentation. Publication, display or distribution of any data or any statements herein is prohibited without prior written approval of the Crops Research Division, ARS, USDA, and the cooperation agency or agencies concerned.

Copies of this report were submitted to the following:

Two copies (1 and 2):
Forage & Range Branch
Crops Research Division
Plant Industry Station
Beltsville, Maryland

One copy (3):
Director
Utah Agricultural Experiment Station
Utah State University
Logan, Utah

One copy (4):
Director
Intermountain Forest & Range Experiment Station
Forest Service, USDA
Ogden, Utah

One copy (5):
Project files
Logan, Utah

TABLE OF CONTENTS

			Page
I.	Introduction and Summary		1
	A.	Technical assistance	5
	B.	Vehicles at Logan, Utah	5
II.	A.	Distribution of Podosporiella verticillata	6
	B.	Distribution of Podosporiella in vegetative types	17
	C.	Control of Podosporiella with Captan 75, Srasan 75, and Semesan	26
	D.	Control of Podosporiella in row plantings and in nylon sleeves in northern and central Utah with selected fungicides	32
III.	A.	Seed germination, seedling emergence, and plant survival at high elevations in central Utah	43
	B.	Revegetation trials on mountain ranges	50
	C.	Vegetative growth of some cool season plants as affected by moisture and temperature	56
	D.	Uniform study for seeding depleted sites on western ranges	61

PASTURE AND RANGE INVESTIGATIONS UNDER ARID, SEMIARID, AND SUBHUMID CONDITIONS

I. Introduction

The following report covers the artificial revegetation investigation conducted in central and northern Utah during 1964. One of the major objectives has been to close out all short-term studies in central Utah and compile and analyze this data so that reports can be prepared. The remaining long-term studies in central Utah will be terminated when the objectives have been satisfied. Most of the active work in northern Utah is related to the phenology, distribution, and control of the fungus Podosporiella verticillata.

CR c6-2. Development of improved forage production on arid grazing lands. The search for new or improved species that can produce more forage and still maintain soil stability on western ranges is continuing. Many of the better and more accessible sites have been successfully seeded by revegetation. However, failures have frequently occurred.

Suitable species are needed to increase forage production, to maintain soil stability, and prevent destructive floods. Species may be well adapted to a particular climate or soil, but still fail because of other environmental factors. This has led to an effort to distinguish between those inherent climatic and edaphic factors which must be met by species selection as opposed to factors such as grazing use, insects, rodents, and disease.

Revegetation of the arid shadscale zone in Utah and Nevada is not practical with present species and methods. Crested wheatgrass and Russian wildrye which have shown the most promise of the introduced grasses usually develop good seedling stands but perish during drought years. Native shrubs have withstood the frequent droughts much better than most native and introduced grasses. Good stands of these shrubs have been difficult to obtain due to one or more of the following: drought, low seed viability, seed dormancy, frost damage to seedlings, and rodent and insect damage to seedlings.

A range planting with nine legumes in mixture with each of four grasses has shown that mountain brome was most compatible with the legumes used but this grass is short lived. Production of legumes was least when grown with intermediate wheatgrass. Legumes growing with crested wheatgrass and smooth brome produced similar yields. The common alfalfa strains were superior to other legumes but Astragalus cicer also made a good showing. A. falcatus and siberian alfalfa produced fair stands. Lathyrus sylvestris, Lotus corniculatus and Vicia tenufolia failed on this mountain brush site.

CR c6-3. Methods of seeding and establishing forage plants on arid grazing lands. Emphasis during the year has been with studies of the fungus Podosporiella verticillata. Most of this work has been conducted cooperatively with Dr. K. W. Kreitlow. This fungus can infect the seed in any season, but damage has usually been highest in the early fall plantings. It has seriously reduced seed germination, seedling emergence

and plant survival. This fungus has been found throught sagebrush-grass type in the Western States. Seed treatment with Captan 75 at 12 ounces or Arasan 75 at 8 ounces per 100 pounds of seed prior to planting has given effective control.

Suitable establishment practices are necessary for consistently successful and effective revegetation of depleted ranges on which the present plant cover is not adequate for soil protection or is of low forage value. Seed and seedling diseases, low precipitation, dry summer, sandy soil, acid soil, steep slopes and rough terrain are some of the factors which require special consideration. The reseeding program is expanding into extremes of climate and soils where little is known about reseeding. This magnifies the importance of "know-how" in restoring the vegetation.

Depth of planting studies have shown that most species readily emerge from a 1/2-inch and 1-inch planting depth but emergence for most species is sharply reduced by a 2-inch or greater depth. Wild oat was the only plant emerging from a 6-inch depth. In contrast, seed germination has usually been high at all depths up to 24 inches. Most of this variation in germination appears to be caused by moisture and temperature in the soil at the various depths and not depth of soil.

Date of planting studies have shown that most of the domestic grasses germinate readily throughout the early and late fall when soil moisture was readily available. However, low temperatures and restrictive moisture in the late fall tend to retard seed germination until spring. Seeds of many native species would not germinate in the fall until seed dormancy was broken.

CR c6-6. Physiology of range and pasture plants. Physiological studies on response of plants to environmental factors provide information needed for selection of suitable species and methods and for successful establishment and management. Reasons for specific responses by seeds and plants to certain factors in the environment must be understood to predict behavior from site to site. This understanding will not only assist in selection of species, site, and management, but should also show where modification of certain environmental factors may be desirable.

Soil temperatures at high elevations under a deep snow cover usually remain near 0°C. unless they were heavily frozen prior to covering by the permanent winter snow. These temperatures are favorable for seed germination of many species, limited plant growth, and rapid decomposition of organic matter by fungi and soil organisms.

Seed germination, seedling emergence, and seedling survival studies at high elevations have shown that seeds of many grasses and forbs germinate during the winter and emerge under the snow or soon after spring snowmelt. Most of the domestic and some native species germinated as soon as moisture was available although temperatures were near 0°C. Seeds from many natives such as tarweed and slender wheatgrass did not germinate until seed dormancy was broken. Another group did not germinate until the soil warmed the following spring. Although seed germination has usually been high, seedling emergence has been low. Grass seedling emergence was higher than average emergence for the forbs but some of the forbs classed as relatively undesirable increasers such as toungleaf violet, low larkspur, and springbeauty usually had a

high emergence and survival. The annuals, tarweed, douglas knotweed, collensia and similar plants, had a high emergence and produced a seed crop.

I-A. Foreign Visitors and Technical Assistance

A total of 41 hours was spent giving technical assistance and reviewing research findings with extension workers, action agencies and private groups. No official time was spent with foreign visitors.

I-B. Vehicles at Logan, Utah

1965 truck pickup, 1/2 ton, Dodge, V-13012-ARS, license A-112191. Mileage on March 1, 1965 was 450. New condition.

II-A. Distribution of Podosporiella verticillata.

Additional information was obtained on the distribution of this fungus in the eastern part of the United States, the Plains States, and the Eastern States. Nylon strips containing seed of Delmar wheat, crested wheatgrass, intermediate wheatgrass, slender wheatgrass and smooth brome were prepared and submersed in a 1% clorox solution for 15 seconds and then washed in tap water and dried. Bags were then wrapped in foil to prevent possible contamination by spores of Podosporiella prior to planting.

Treated strips were planted at 13 locations in 10 central or western states. People at the locations shown in Table 1 made the plantings, recorded information on soil, site, presence or absence of cheatgrass brome (Bromus tectorum) and other vegetation, removed the strips from the soil in the spring of 1964 and returned them to Logan, Utah, for inspection. Planting depth requested was 1 1/4 inches (3 cm.) with a minimum soil covering of 1 inch and a maximum soil covering of 1 1/2 inches. We requested that seeds be planted during September or early in October.

Some infection with Podosporiella was found on seed planted in Arizona, California, Colorado, Idaho, Nevada, New Mexico, North Dakota, Oregon and Utah. No infected seeds were found in material planted in Oklahoma. Degree of infection varied from low in North Dakota and New Mexico to relatively high in Oregon, Idaho and Utah. Since the seeds planted at these locations had been surface sterilized, it is assumed

Table 1. Percent of seeds (4 grasses and wheat) infected with Podosporiella verticillata in the spring of 1964 at 12 locations (see attached sheets for descriptions of locations).

State Individual Species	Arizona Bleak 1/	California Cornelius 2/	Colorado McGinnies 3/	Idaho Klomp 4/	C. Nevada Eckert 5/	New Mexico Herbel 6/
Crested wheatgrass						
1	0 d	1 d	10 b	28 a	18 a	0 d
2	0 c	0 d	13 b	50 a	19 a	0 d
3	0 d		3 b	56 a		0 d
4	0 d					0 d
5	0 d					0 d
Average	0.0	0.5	8.7	44.7	18.5	0.0
Intermediate wheatgrass						
1	2 d	1 d	5 b	37 a	22 a	0 d
2	0 c	0 d	26 b	40 a	23 a	0 d
3	0 d		5 b	35 a		0 d
4	0 d					1 d
5	0 d					1 d
Average	0.4	0.5	12.0	37.3	22.5	0.4
Slender wheatgrass						
1	0 d	1 d	1 b	4 a	4 a	0 d
2	0 c	0 d	1 b	4 a	1 a	0 d
3	0 d		0 b	11 a		0 d
4	0 d					0 d
5	0 d					0 d
Average	0.0	0.5	0.7	6.3	2.5	0.0

1/-12/ Footnotes on attached sheets.

a. Bromus tectorum reported abundant.
b. Bromus tectorum reported moderate.
c. Bromus tectorum reported slight to moderate.
d. Bromus tectorum reported absent.

7

Table 1 . --(continued)

State Individual Species	North Dakota Rogler 7/	Oklahoma McIlvain 8/	Oregon Sneva 9/	N. Utah Bleak 10/	C. Utah Bleak 11/	S. Utah Bleak 12/
Crested wheatgrass						
1	0 d	0 d	79 a	48 a	82 a	6 c
2	0 d	0 d	76 a	24 a	48 b	21 b
3		0 d	60 a	59 a	57 a	0 d
4				16 b	64 a	4 b
5				10 b	77 a	1 d
Average	0.0	0.0	71.7	31.4	65.6	6.4
Intermediate wheatgrass						
1	0 d	0 d	84 a	58 a	84 a	3 c
2	2 d	0 d	66 a	24 a	75 b	18 b
3		0 d	57 a	40 a	68 a	0 d
4				22 b	36 a	4 b
5				11 b	84 a	0 d
Average	1.0	0.0	69.0	31.0	69.4	5.0
Slender wheatgrass						
1	0 d	0 d	15 a	4 a	6 a	1 c
2	0 d	0 d	24 a	3 a	12 b	0 b
3		0 d	13 a	7 a	5 a	0 d
4				6 b	1 a	4 b
5				1 b	43 a	1 d
Average	0.0	0.0	17.3	4.2	13.4	1.2

1/-12/ Footnotes on attached sheets.

a. *Bromus tectorum* reported abundant.
b. *Bromus tectorum* reported moderate.
c. *Bromus tectorum* reported slight to moderate.
d. *Bromus tectorum* reported absent.

Table 1 . --(continued)

State Individual Species	Arizona Bleak 1/	California Cornelius 2/	Colorado McGinnies 3/	Idaho Klomp 4/	C. Nevada Eckert 5/	New Mexico Herbel 6/
Smooth brome						
1	0 d	6 d	36 b	64 a	23 a	1 d
2	0 c	3 d	67 b	77 a	35 a	0 d
3	0 d		4 b	86 a		0 d
4	0 d					0 d
5	0 d					0 d
Average	0.0	4.5	35.7	75.7	29.0	0.2
Delmar wheat						
1	0 d	4 d	4 b	29 a	18 a	1 d
2	0 c	0 d	4 b	53 a	2 a	0 d
3	0 d		7 b	50 a		0 d
4	0 d					0 d
5	0 d					0 d
Average	0.0	2.0	5.0	44.0	10.0	0.2
Grand Average	0.2	1.6	12.4	41.6	16.5	0.2

1/-12/ Footnotes on attached sheets.

a. Bromus tectorum reported abundant.
b. Bromus tectorum reported moderate.
c. Bromus tectorum reported slight to moderate.
d. Bromus tectorum reported absent.

Table 1. --(continued)

State Individual Species	North Dakota Rogler 7/	Oklahoma McIlvain 8/	Oregon Smeva 9/	N. Utah Bleak 10/	C. Utah Bleak 11/	S. Utah Bleak 12/
Smooth brome						
1	0 d	0 d	67 a	60 a	97 a	14 c
2	3 d	0 d	95 a	56 a	85 b	26 b
3		0 d	87 a	63 a	91 a	0 d
4				35 b	93 a	17 b
5				25 b	93 a	0 d
Average	1.5	0.0	83.0	47.8	91.8	11.4
Delmar wheat						
1	0 d	0 d	12 a	14 a	37 a	6 c
2	0 d	0 d	21 a	18 a	32 b	14 b
3		0 d	45 a	33 a	40 a	0 d
4				21 b	25 a	3 b
5				2 b	29 a	0 d
Average	0.0	0.0	26.0	17.6	32.6	4.6
Grand Average	0.5	0.0	53.4	26.4	54.6	5.7

1/-12/ Footnotes on attached sheets.

a. Bromus tectorum reported abundant.
b. Bromus tectorum reported moderate.
c. Bromus tectorum reported slight to moderate.
d. Bromus tectorum reported absent.

1/ Arizona - A. T. Bleak

Plot 1.
Planted: 9-18-63
Removed: 6-3-64
Site: Entrance to South Buffalo Refuge on Highway 89.
Vegetation: Bouteloua spp., Hilaria spp., Gutierrezia sarothrae.

Plot 2.
Planted: 9-18-63
Removed: 6-3-64
Site: Created wheatgrass seeding on Kaibab N. F., 12 miles south of Fredonia on Jacob Lake Ranger District.
Vegetation: Artemisia tridentata, Sitanion hystrix, Gutierrezia sarothrae, Bromus tectorum, Bromus rubens.

Plot 3.
Planted: 9-18-63
Removed: 6-3-64
Site: Burrows Allotment, near Jacob Lake, Kaibab N. F.
Vegetation: Pinus ponderosa, Artemesia tridentata, Muhlenbergia spp., Sitanion hystrix.

Plots 4 and 5.
Planted: 9-18-63
Removed: 6-23-64
Site: On Highway 89 near Glen Canyon.
Vegetation: Sporobolus spp., Hilaria jamesii, and Franseria dumbosa.

2/ California - D. R. Cornelius

Plots 1 and 2.
Planted: early December 1963
Removed: June 1964
Site: Three miles north of Highway 40 on the cut off to Winters, California. (Western edge of Sacramento Valley)
Vegetation: Elymus caput-medusae, 40%; Bromus mollis, 40%; Bromus rigidus, 10%; Avena barbata, 5%; Lolium multiflorum, 3%; and Erodium, 2%.

3/ Colorado - William J. McGinnis

Plots 1 and 2.
Planted: 10-7-63
Removed: 6-3-64
Site: Central Plains Experimental Range near Ft. Collins. Bottomland soil.
Vegetation: Kochia scoparia, Salsola kali tenuifolia and Bromus tectorum and Atriplex canescens.

3/ Colorado - William J. McGinnis continued.

Plot 3.
Planted: 10-7-63
Removed: 6-3-64
Site: West of Ft. Collins on abandoned cropland with fine sandy soil.
Vegetation: Bromus tectorum and other annuals.

4/ Idaho - G. J. Klomp

Plots 1 and 2.
Planted: 9-17-63
Removed: 6-12-64
Site: Four miles north of Wendell, Idaho, on a sandy loam.
Vegetation: Bromus tectorum, Salsola kali tenuifolia, Artemisia tridentata and Agropyron cristatum.

Plot 3.
Planted: 9-17-63
Removed: 6-12-64
Site: North of Twin Falls and 1.6 miles north of Perrine bridge on Highway 93.
Vegetation: Bromus tectorum, Agropyron cristatum, Salsola kali tenuifolia and Artemisia tridentata.

5/ Nevada - R. E. Eckert

Plot 1.
Planted: 9-22-63
Removed: 5-22-64
Site: Mt. Rose Road south of Reno, soil is rocky sandy loam.
Vegetation: Artemisia tridentata, 5% cover; Chrysothamnus viscidiflorus, 10% cover; and Bromus tectorum, 50% cover.

Plot 2.
Planted: 9-22-63
Removed: 5-22-64
Site: Old Virginia City Road, soil is rocky sandy loam.
Vegetation: Artemisia tridentata, 15% cover; Prunus andersonii, 3% cover; Bromus tectorum, 10% cover, and Sitanion hystrix, 3% cover.

6/ New Mexico - C. H. Herbel

Plots 1 to 5.
Planted: 10-1-63
Removed: 6-3-64
Site: Jornada Experimental Range
1. Dona Ana - Dagget gravelly sandy loam. Larrea tridentata.
2 & 3. South boundary, Hoban silt loam, Tobosa and burrowgrass.
4. Exclosure A, Bucklebar loam sand, Mesa dropseed and sixweeks grama.
5. Rabbit, coppice duneland, mesquite, and fourwing saltbush.

7/ North Dakota - G. A. Rogler

Plot 1.
Planted: 9-16-63
Removed: 5-25-64
Site: Northern Great Plains Field Station, Mandan.
Soil: Native sod broken out in 1950. Heavy soil.
Vegetation: Agropyron smithii (western wheatgrass), Stipa comata (needle-and-thread), Bouteloua gracilis (blue gama). No Bromus tectorum.

Plot 2.
Planted: 9-16-63
Removed: 5-25-64
Site: Northern Great Plains Field Station, Mandan.
Soil: High organic soil.
Vegetation: Surrounded by Bromus inermis (bromegrass) No Bromus tectorum.

8/ Oklahoma - E. M. McIlvain

Plot 1.
Planted: 9-24-63
Removed: 6-6-64
Site: 4½ miles north of Fargo, Oklahoma.
Soil: Potter-Manaker loam.
Vegetation: Side-oats grama, 80%; sand dropseed, 10%; and hairy grama, 10%.

Plot 2.
Planted: 9-24-63
Removed: 6-6-64
Site: 12 miles south of Buffalo, Oklahoma.
Soil: Quinlan (red).
Vegetation: Side-oats grama, 85%; little bluestem, 10% and silver beardgrass, 5%.

8/ Oklahoma - K. H. McIlvain continued.

Plot 3.
Planted: 9-24-63
Removed: 6-6-64
Site: Southern Great Plains Field Station, Pasture 21 - grazed area. Ft. Supply, Oklahoma, U. S. Range.
Soil: Pratt LFS.
Vegetation: Blue grama, 90%; and sand dropseed, 10%.

9/ Oregon - F. A. Sneva

Plots 1, 2 and 3.
Planted: 9-20-63
Removed: 5-20-64
Site: Range 14, sprayed for brush in 1952.
Vegetation: Agropyron spicatum (bluebunch wheatgrass), Festuca idahoensis (Idaho fescue), Koleria, Sitanion hystrix (squirrel tail), Poa secunda, Bromus tectorum (cheatgrass).

10/ Northern Utah - A. T. Bleak

Plots 1 to 5.
Planted: 9-30-63
Removed: 4-6 to 5-22-64
Site: Green Canyon Nursery, Logan.
Elevation: 4750 ft.
Vegetation: Heavy Bromus tectorum, Secale cereale, Artemisia tridentata, Agropyron spicatum.

11/ Central Utah - A. T. Bleak

Plots 1 to 5.
Planted: 9-27-63
Removed: 4-17 to 5-26-64
Site: Rasmusson's Field, Ephraim Canyon
Soil: Sandy loam.
Elevation: 5,600 ft.
Vegetation: Bromus tectorum, Artemisia tridentata, Sitanion hystrix, Agropyron spicatum, Juniperus osteosperma.

12/ Southern Utah and southern Nevada - A. T. Bleak

Plot 1.
Planted: 9-19-63
Removed: 6-4-64
Site: Mormon Wells, Highway 91
Vegetation: Larrea tridentata, Eriogonum spp., trace of Bromus tectorum.

Plot 2.
Planted: 9-19-63
Removed: 6-4-64
Site: Castle Cliff on Highway 91
Vegetation: Clistoyucca brevifolia, Coleogyne ramosissima, Sitanion hystrix and Bromus tectozum.

Plot 3.
Planted: 9-20-63
Removed: 6-5-64
Site: 1/2 mile east of St. George
Vegetation: Larrea tridentata, Prosopis glandulosa.

Plot 4.
Planted: 9-20-63
Removed: 6-5-64
Site: Hurricane-Zion National Park turnoff on Highway 91.
Vegetation: Coleogyne ramosissima, Bromus tectorum, Eriogonum spp.

Plot 5.
Planted: 9-19-63
Removed: 6-4-64
Site: Five miles south of Mesquite on Highway 91.
Vegetation: Larrea tridentata, Hilaria spp., Eriogonum spp., and Franseria dumosa.

that Podosporiella was present in the soil at these locations. In contrast, the surface sterilized seed planted in Oklahoma was not infected with Podosporiella in 1964 although a few infected seeds had been found in the material returned in 1963. The material returned in 1963 had not been surface sterilized prior to planting.

Results in 1964 were similar to 1963 in that infection was relatively high where plantings were made in the sagebrush-grass vegetative zone. Also, results were similar to the 1963 results in that the degree of infection was usually high where cheatgrass brome was abundant. One apparent exception to a high seed infection in the presence of abundant cheatgrass was found in northern Arizona and southeastern Utah. Additional plantings have been made near Kanab, Utah, and in northern Arizona to resample this area.

It now appears that cheatgrass favors a high population of Podosporiella spores in the soil. Although seed of cheatgrass is susceptible to this fungus, no eradication of cheatgrass by this fungus has been observed. This appears to be due to the large numbers of seed produced by cheatgrass, and the rapid germination of the cheatgrass seed when moisture is available. Synnemata of Podosporiella can often be observed protruding from cheatgrass seeds caught in the plant litter at or above the soil surface where moisture was not adequate for rapid germination.

Additional strips were planted in Indiana, New Hampshire, Pennsylvania, Minnesota and at Beltsville, Maryland. This work was handled by Dr. K. W. Kreitlow. He reported that none of the seeds planted and examined showed any sign of Podosporiella infection.

II-B. Distribution of Podosporiella in vegetative types.

Additional information on distribution of this fungus within vegetative types in Utah and adjoining states was obtained. Past work has shown that this fungus is especially abundant in the sagebrush-grass type but appeared to be less abundant in other vegetative types. Plantings were made in the fall of 1963 to provide information on the distribution of this fungus in the various vegetative zones common in Utah.

Untreated seed of crested wheatgrass, intermediate wheatgrass, slender wheatgrass, smooth brome, and Delmar wheat in nylon sleeves was placed within selected vegetative types at two or more locations. Seed in nylon sleeves was placed in shallow trenches and the original soil covering was replaced to provide a 1-inch soil covering (planting depth) over the seed. Three or more replications were placed in each of the vegetative types sampled. Replications were placed in close proximity at some locations, but were separated by several miles at other locations.

Table 2 shows the number of infected seeds observed in each replication within a specific vegetation zone and relative abundance of cheatgrass at each planting site. Results in 1964 were similar to the results in 1963.

This fungus was especially abundant in the sagebrush-grass type. Degree of infection in the shadscale or salt-desert type was less than in comparable areas sampled in 1963. Direct field observations and a few nylon strips placed in the pinyon-juniper type in central and southern Utah indicated a moderate to abundant infection potential by this fungus,

Table 2. Percentage infection on seed of five species by Podosporiella verticillata planted at various locations in Utah within five vegetative zones.

Locations 1/	Bromus tectorum 2/	Species: Crested wheatgrass	Intermediate wheatgrass	Slender wheatgrass	Smooth brome	Delman wheat	Average
Shadscale areas							
Northern Utah - 1	d	0	0	0	5	2	1.4
Northern Utah - 2	b	19	4	0	12	5	8.0
Northern Utah - 3	b	2	6	0	8	0	3.2
Northern Utah - 4	c	1	0	1	1	0	0.6
Central Utah - 5	a	1	2	0	3	2	1.6
Central Utah - 6	a	9	4	0	9	13	7.0
Central Utah - 7	a	6	14	0	19	3	8.4
Average		5.4	4.3	0.1	8.1	3.6	4.3
Sagebrush areas							
Northern Utah - 1	b	36	28	24	70	40	39.6
Northern Utah - 2	a	53	59	3	94	18	45.4
Northern Utah - 3	a	9	20	2	60	2	18.6
Central Utah - 4	b	11	19	0	33	12	15.0
Central Utah - 5	b	45	25	1	72	23	33.2
Central Utah - 6	b	32	17	1	53	19	24.4
Southern Utah - 7	a	85	83	10	79	79	67.2
Average		38.7	35.9	5.9	65.9	27.6	34.8
Mountain Brush							
Northern Utah - 1	c	15	12	2	28	12	13.8
Northern Utah - 2	c	67	63	1	41	7	35.8
Central Utah - 3	b	8	18	0	26	5	11.4
Central Utah - 4	b	7	14	0	17	3	8.2
Central Utah - 5	c	5	6	0	9	3	4.6
Average		20.4	22.6	0.6	24.2	6.0	14.8

1/ See attached sheets for descriptions of locations.

2/ Abundance of Bromus tectorum.
a. Abundant Bromus tectorum.
b. Moderate Bromus tectorum.
c. Little Bromus tectorum.
d. No Bromus tectorum.

Table 2 . Percentage infection on seed of five species by Podosporiella verticillata planted at various locations in Utah within five vegetative zones.

Locations 1/	Bromus tectorum 2/	Species: Crested wheatgrass	Intermediate wheatgrass	Slender wheatgrass	Smooth brome	Pelmar wheat	Average
		----------Aspen Fir----------					
Northern Utah - 1	d	0	0	0	0	0	0.0
Northern Utah - 2	c	24	27	2	59	10	24.4
Northern Utah - 3	c	1	1	0	2	10	2.8
Central Utah - 4	d	0	0	0	0	0	0.0
Central Utah - 5	d	0	0	0	0	0	0.0
Central Utah - 6	d	0	0	0	0	0	0.0
Average		4.2	4.7	0.3	10.2	3.3	4.5
		----------Spruce Fir----------					
Northern Utah - 1	d	9	20	0	15	6	10.0
Northern Utah - 2	d	16	11	0	15	7	9.8
Northern Utah - 3	d	0	2	0	1	0	0.6
Northern Utah - 4	d	0	0	0	0	0	0.0
Northern Utah - 5	d	0	1	0	1	0	0.4
Central Utah - 6	d	0	0	0	0	0	0.0
Central Utah - 7	d	0	0	0	0	0	0.0
Central Utah - 1	d	0	0	0	0	0	0.0
Average		3.1	4.2	0.0	4.0	1.6	2.6

1/ See attached sheets for descriptions of locations.

2/ Abundance of Bromus tectorum.
a. Abundant Bromus tectorum.
b. Moderate Bromus tectorum.
c. Little Bromus tectorum.
d. No Bromus tectorum.

1/ Descriptions of locations.

---Shadscale areas---

Plot 1.
Planted: 9-24-63
Removed: 5-21-64
Site: 14.8 miles south of Snowville.
Soil: Alkali plains.
Vegetation: Atriplex confertifolia with barren interspaces except for a few small plants of Halogeton glomeratus.

Plots 2 and 3.
Planted: 9-24-63
Removed: 5-21-64
Site: 15.7 miles south of Snowville.
Soil: Clay loam
Vegetation: Atriplex confertifolia with considerable Bromus tectorum and Lepidium spp.

Plot 4.
Planted: 9-24-63
Removed: 5-21-64
Site: 17.7 miles south of Snowville.
Soil: Clay loam
Vegetation: Sarcobatus vermiculatus with scattered Atriplex confertifolia and a few plants of Halogeton glomeratus, Lepidium spp. and Bromus tectorum.

Plots 5, 6 and 7.
Planted: 9-18-63
Removed: 5-13-64
Site: Gunnison enclosure - used for a sheep-holding pen. No. 5 was out of soil and wheat was uncovered in No. 7.
Soil: Sandy loam
Vegetation: Atriplex confertifolia with considerable Bromus tectorum.

---Sagebrush areas---

Plot 1.
Planted: 10-3-63
Removed: 5-11-64
Site: Green Canyon Forest Nursery
Soil: Clay loam
Vegetation: Artemisia tridentata with abundant Bromus tectorum and some Agropyron spicatum.

1/ Descriptions of locations - Sagebrush areas continued.

Plot 2.
Planted: 10-3-63
Removed: 5-11-64
Site: Green Canyon native range.
Soil: Sandy loam
Vegetation: Abundant Artemisia tridentata with abundant Bromus tectorum and some Agropyron spicatum.

Plot 3.
Planted: 10-3-63
Removed: 5-11-64
Site: Shooting range above River Heights.
Soil: Sandy loam
Vegetation: Artemisia tridentata with abundant Bromus tectorum.

Plots 4-6.
Planted: 9-18-63
Removed: 5-26-64
Site: Sorenson's Field - Ephraim, Utah.
Soil: Clay loam
Vegetation: Planted grasses with moderate to heavy Bromus tectorum.

Plot 7.
Planted: 9-19-63
Removed: 6-4-64
Site: South city limits - Cedar City, Utah.
Soil: Clay loam
Vegetation: Heavy Bromus tectorum.

---Mountain Brush---

Plots 1 and 2.
Planted: 10-3-63
Removed: 7-1-64
Site: Logan Canyon - Twin Bridges.
Soil: Sandy clay loam
Vegetation: Many shrub species and abundant Agropyron spicatum, Elymus cinereus, Poa spp. and some Bromus tectorum.

Plots 3-5.
Planted: 9-18-63
Removed: 5-26-64
Site: Majors Flat, Ephraim Canyon.
Soil: Clay loam
Vegetation: Many planted grasses and light to moderate amounts of Bromus tectorum.

1/ Descriptions of locations.

----------Aspen-fir----------

Plot 1.
Planted: 9-26-63
Removed: 7-1-64
Site: Mud Flat enclosure - large opening in aspen type.
Soil: Clay
Vegetation: Many native and planted grasses.

Plots 2-3.
Planted: 9-26-63
Removed: 7-1-64
Site: Tony Grove Station and Franklin Basin Turnoff
Soil: Clay loam
Vegetation: Aspen canopy with many native grasses and a few scattered plants of Bromus tectorum in vicinity.

Plots 4-6.
Planted: 9-26-63
Removed: 7-7-64
Sites: Bluebell Flat, aspen reseeding enclosure, and Headquarters Station.
Soil: Clay loam
Vegetation: Aspen canopy with many native and planted grasses.

----------Spruce-fir----------

Plots 1-3.
Planted: 10-3-63
Removed: 7-1-64
Site No. 1: Cheney Creek - Blacksmith Fork Road.
Site No. 2: Turnoff from Highway 89 to Beaver Mountain ski area.
Site No. 3: One mile east of Beaver Mountain ski area turnoff.
Soil: Clay loam
Vegetation: Openings in stands of spruce-fir, or lodgepole pine. Considerable Artemisia tridentata with various native grasses.

Plots 4-5.
Planted: 10-15-63
Removed: 7-1-64
Site: Franklin Basin enclosure.
Soil: Clay loam
Vegetation: Many native and planted grasses.

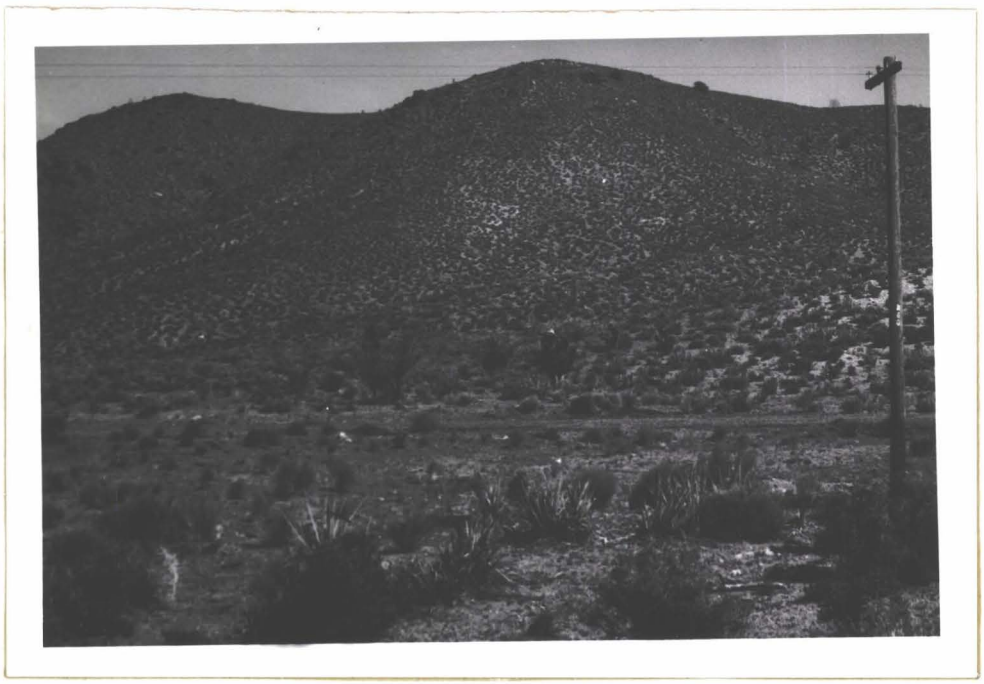
1/ Descriptions of locations - Spruce-fir area continued.

Plots 6-8.
Planted: 9-26-63
Removed: 7-7-64
Sites: No. 6 at Area A Watershed in Ephraim Canyon.
No. 7 at Summit revegetation enclosure.
No. 8 at Philadelphia Flat enclosure.
Soil: Clay loam
Vegetation: Openings in spruce-fir type. Many planted and native grasses on all areas.

usually depending on abundance of cheatgrass. In general relative abundance of Podosporiella was very high where cheatgrass had invaded following tree eradication.

This fungus was not observed on any seed planted in the aspen-fir and spruce-fir types in central Utah although some infected seeds were found in the mountain-brush zone. These results are identical to results in 1963. In northern Utah, moderate to heavy amounts of this fungus were observed in the mountain-brush type and some infection was observed at two locations in the aspen-fir type. As shown in Table 2, most of the spruce-fir sites in northern Utah contained some infected seeds. The spruce-fir sites in northern Utah are not well defined and frequently contain an understory of grass and sagebrush. Sagebrush with a grass understory, mixed with mountain-brush species on favorable sites, occupies much of the higher rangelands in northern Utah. Although this is not the typical sagebrush-grass type occurring in the valleys and on the foothills, it is similar. The infection potential in this upper sagebrush type is usually low to moderate compared with a high infection potential in lower sagebrush-grass type.

Podosporiella in limited amounts was also found in the lower Sonaran Vegetation Zone in southern Nevada, northern Arizona and northern Utah. This vegetation zone is typified by presence of creasote-bush (Larrea tridentata) as shown in Figure 1. However, it was quite abundant in a transition zone in southern Utah and northern Arizona where Joshua-trees (Clistoyucca brevifolia) and blackbrush (Coleogyne ramosissima) were found as shown in Figure 2.



Figures 1 & 2. The upper photo shows a creosote-brush type in southern Utah where some infection by Podosporiella was found. The lower photo shows a transition zone in northern Arizona where degree of infection by Podosporiella was moderate.

II-C. Control of Podosporiella with Captan 75, Arasan 75 and Semesan.

Previous studies have shown that Podosporiella can be controlled by treating grass seeds with relatively high rates of selected fungicides. A refined study to determine the relative control of Captan 75, Arasan 75, and Semesan at several locations was established in the fall of 1963.

Seeds of crested wheatgrass, intermediate wheatgrass, slender wheatgrass, smooth brome and Delmar wheat were counted into units containing 100 seeds of a single species treated with a specified fungicide. Seeds of each of the above species were placed in a separate compartment in a nylon sleeve. The compartments or pockets were closed and sewn to prevent loss of seed. Each nylon sleeve was wrapped in foil to prevent contamination, mixing of fungicides, or loss of fungicide.

Seeds were treated with the fungicides as follows: Captan 75, 8 ounces per 100 pounds of grass seed and 2 ounces per 100 pounds of wheat; Arasan 75, 6 ounces per 100 pounds of grass seed and 2 ounces per 100 pounds of wheat; and Semesan, 6 ounces per 100 pounds of grass seed and 2 ounces per 100 pounds of wheat. All fungicides were applied to the seed as a dry powder.

Three replications of treated seeds and an untreated control in nylon sleeves were sent to Mr. W. J. McGinnies at Fort Collins, Colorado; Mr. G. J. Klomp at Twin Falls, Idaho; Dr. R. E. Eckert at Reno, Nevada; Mr. F. L. Sneva at Burns, Oregon in the fall of 1963. Additional units (5 replications) were planted near Logan, Utah, and near Ephraim, Utah, in the fall of 1963. All units were planted in the sagebrush-grass type at a depth of approximately 1 inch. Nylon sleeves were removed from the

soil in the spring of 1964 and returned to Logan, Utah, for examination. A detailed description of the planting sites can be found in Section II-A in the appendage to Table 2. Number of seeds infected with Podosoriella is shown in Table 3.

All fungicide treatments gave fair to good control in the Colorado, Idaho, and Nevada plantings. In Oregon all fungicides gave fair control, but Captan 75 and Semesan gave better control than Arasan 75. As shown in Table 3, a surprising number of treated seeds were infected by Podosporiella at the central Utah planting site. At this location, Semesan gave slightly better control than Arasan 75 and considerably better control than Captan 75. The variation in control by the respective fungicides at the various locations is difficult to explain because all seeds of a single species receiving a specified fungicide were from a single bulk seed treatment. Difference must have been due to site factors such as precipitation, soil moisture and soil temperatures.

The initial study demonstrated the need for studies on rates of fungicides necessary to control Podosporiella where seeds remain in the soil during the fall and winter or for several months in the summer prior to germinating.

Captan 75 was used to treat smooth brome seed at several rates as shown in Table 4. The 8 ounce rate was used to compare dry (dust) treatment with the wet treatment (slurry). Treated seeds were tested in the greenhouse and in the field at Green Canyon nursery. The slurry treatment gave slightly better control in the greenhouse, but there was little difference between treatments at the field location. Slurry treatment

Table 8. Percent of seed treated with fungicides that were infected with Podosporiella verticillata when removed and after 21 days in the germinator.

State	Colorado[1]		Idaho[2]		Nevada[3]		Oregon[2]		C. Utah[4]		N. Utah[4]	
Location	Ft. Collins		Twin Falls		Reno		Burns		Ephraim		Logan	
Individual	McGinnies		Klomp		Eckert		Snava		Bleak		Bleak	
Species and Treatments	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.
Crested wheatgrass												
Arasan 75	0.0	0.0	0.0	0.0	0.0	0.0	5.3	5.7	5.0	6.0	0.2	0.2
Captan 75	1.3	1.3	0.0	0.0	0.0	0.0	0.7	0.7	23.8	29.8	0.6	0.8
Semesan	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	3.4	6.0	6.6	7.6
Untreated	7.7	8.7	41.0	44.7	11.0	18.5	69.7	71.7	59.4	65.6	29.2	31.4
Average	2.4	2.6	10.2	11.2	2.8	4.6	18.9	19.5	22.9	26.8	9.2	10.0
Intermediate wheatgrass												
Arasan 75	0.0	0.0	0.0	0.0	0.0	0.0	4.3	5.0	3.2	4.6	0.2	0.4
Captan 75	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	16.4	21.4	0.6	0.8
Semesan	0.0	0.0	1.0	1.0	0.5	0.5	0.3	0.3	0.6	1.8	3.4	4.2
Untreated	9.7	12.0	35.7	37.3	14.5	22.5	64.7	69.0	66.4	69.4	28.2	31.0
Average	2.8	3.3	9.2	9.6	3.8	5.8	17.3	18.6	21.6	24.3	8.1	9.1
Slender wheatgrass												
Arasan 75	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.3	1.4	2.0	0.0	0.2
Captan 75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.6	0.4	0.4
Semesan	0.0	0.0	3.3	3.3	0.0	0.0	0.0	0.0	2.8	3.4	1.2	2.2
Untreated	0.7	0.7	6.0	6.3	2.0	2.5	15.3	17.3	9.2	13.4	3.0	4.2
Average	0.4	0.4	2.3	2.4	0.5	0.6	4.1	4.6	4.0	5.4	1.2	1.8

Table 3 . --(continued)

State Location Individual	Colorado[1] Ft. Collins McGinnies		Idaho[2] Twin Falls Klomp		Nevada[3] Reno Eckert		Oregon[2] Burns Sneva		C. Utah[4] Ephraim Bleak		N. Utah[4] Logan Bleak	
Species and Treatments	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.
Smooth brome												
Arasan 75	2.0	2.0	0.7	0.7	0.0	0.0	1.3	11.7	4.4	7.8	0.0	0.0
Captan 75	0.7	0.7	0.7	0.7	0.0	0.0	2.3	2.3	27.8	41.8	0.0	1.6
Semesan	1.5	1.5	3.0	3.3	0.5	0.5	2.3	2.7	6.0	8.6	5.8	7.6
Untreated	33.0	35.7	71.7	75.7	21.0	29.0	8.7	83.0	85.8	91.8	46.4	47.8
Average	9.3	10.0	19.0	20.1	5.4	7.4	3.6	24.0	31.0	37.5	13.0	14.2
Delmar wheat												
Arasan 75	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	1.2	1.6	0.0	0.0
Captan 75	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	1.4	1.4	0.0	0.0
Semesan	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.2	0.6	5.6	5.6
Untreated	4.0	5.0	40.6	44.0	8.0	10.0	12.7	26.0	25.6	32.6	15.8	17.6
Average	1.0	1.2	10.4	11.2	2.0	2.5	3.2	6.6	7.1	9.0	5.4	5.8
All species												
Arasan 75	0.6	0.6	0.1	0.1	0.0	0.0	2.4	4.3	3.0	4.4	0.1	0.2
Captan 75	0.7	0.7	0.2	0.2	0.0	0.0	0.6	0.6	14.4	19.4	0.3	0.7
Semesan	0.4	0.4	1.6	1.6	0.2	0.2	0.5	0.6	2.6	4.1	4.5	5.4
Untreated	11.0	11.5	39.0	41.6	11.3	16.5	34.2	53.4	49.3	54.6	24.5	26.4
Average	3.2	3.3	10.2	10.9	2.9	4.2	9.4	14.7	17.3	20.6	7.4	8.2

1/ Two replications of Arasan 75 and Semesan.
Three replicetions of Captan 75 and Untreated.

2/ Three replications.

3/ Two replications.

4/ Five replications.

Table 4. Percent of smooth brome seed infected with Podosporiella verticillata following seed treatment at several rates and planting in infected soil in the greenhouse and at the Green Canyon study area.

Location	Treatments Captan 75					
	0 oz.1/ Check	8 oz. Dry	8 oz. Slurry	12 oz. Slurry	16 oz. Slurry	24 oz. Slurry
Greenhouse	47	3	0	0	0	0
	69	0	1	0	0	0
	51	2	1	0	0	0
	73	2	2	0	0	0
	42	1	0	0	0	0
Average	56.4	1.6	0.8	0.0	0.0	0.0
Green Canyon	29	1	0	0	0	0
	56	1	3	0	0	0
	37	0	0	0	0	0
	39	0	0	0	0	0
	42	0	0	0	0	0
Average	40.6	0.4	0.6	0.0	0.0	0.0

1/ Ounces per 100 pounds of grass seed.

with Captan 75 at the 12 ounce rate per 100 pounds of seed gave complete control of this fungus without apparent damage to the seeds or seedling. Heavier rates (16 ounce and 24 ounce) also gave complete control. Seeds or seedlings did not appear to be damaged by heavier rates of Captan 75. However, seedling emergence with the 16 ounce and the 24 ounce treatment was slower both in the greenhouse and at Green Canyon. It now appears that the 8 ounce treatment rate for Captan 75 is adequate for spring plantings or where seeds will not remain in the soil for extended periods prior to germination. The 12 ounce treatment rate is recommended when seeds will remain in the soil for extended periods.

Arasan 75 seed treatment was included in this study at rates of 6 ounces and 8 ounces per 100 pounds of seed. As shown below, a few seeds were infected when the 6 ounce treatment rate was used, but the 8 ounce rate per 100 pounds of seed gave complete control both in the greenhouse and at Green Canyon. Arasan 75 was applied as a dust (dry).

Arasan 75 per 100 pounds of smooth brome seed

	0 oz.	6 oz.	8 oz.
Greenhouse	47	1	0
	69	1	0
	51	0	0
	73	0	0
	42	2	0
Average	56.4	0.8	0.0
Green Canyon	29	1	0
	56	0	0
	37	1	0
	39	1	0
	42	0	0
Average	40.6	0.6	0.0

II-D. Control of Podosporiella in row plantings and in nylon sleeves in northern and central Utah with selected fungicides.

Five seed treatments were applied to seeds of five species planted in rows and in nylon sleeves at two locations. Seed treatments included Captan 75 at a rate of 8 ounces, Arasan 75 at a rate of 6 ounces and Semesan at a rate of 6 ounces per 100 pounds of grass seed (Figures 3 and 4). Wheat was treated at a rate of 2 pounds per 100 pounds of seed for each fungicide. HCB 40% (Hexachlorobenzine) and Terraclor 75% (Pentachloronitrobenzine) was thoroughly mixed with soil from the rows and seeds were planted so that some of the fungicide was below and some above the seed. These chemicals were mixed with the soil at a rate of 2 pounds per acre based on 12-inch rows.

Five replications of crested wheatgrass, intermediate wheatgrass, slender wheatgrass, smooth brome and Delmar wheat were planted in rows and also in nylon sleeves at both locations. Each replication contained 100 seeds of each species. Plantings were made in central Utah on September 27, and in northern Utah on September 30, 1963.

Emergence counts were made in northern Utah at intervals, beginning on October 25, 1963. Conditions were especially favorable for fall seed germination and many seedlings had emerged by October 5. On October 25 seedling emergence appeared to be nearly complete for wheat. All of the other species except slender wheatgrass averaged over 50% emergence (Table 5.) This rapid seed germination and seedling emergence did not allow the Podosporiella to thoroughly infect the seed and thus reduce germination and emergence. Seed treatment under these conditions did

Figures 3 and 4. Treated and untreated seeds were planted in rows and in nylon sleeves in northern Utah and near Ephraim in central Utah.

Table 5. Emergence from treated seed in the fall of 1963 and number of living plants in the spring and summer of 1964 at Green Canyon Nursery.

Date	Untreated	Fungicide: Arasan	Captan	Semesan	HCB	Terraclor	Average
Crested Wheatgrass							
Fall 1963[1]	59	59	56	55	50	47	54.3
Spring 1964[2]	5	16	13	15	6	6	10.2
Summer 1964[3]	3	9	8	10	3	4	6.2
Average	22.3	28.0	25.7	26.7	19.7	19.0	23.6
Intermediate Wheatgrass							
Fall 1963	70	79	72	71	72	63	71.2
Spring 1964	42	59	52	54	45	36	48.0
Summer 1964	38	53	49	51	44	34	44.8
Average	50.0	63.7	57.7	58.7	53.7	44.3	54.7
Slender Wheatgrass							
Fall 1963	0	0	0	0	0	0	0.0
Spring 1964	15	11	16	17	13	17	14.8
Summer 1964	49	51	55	53	47	41	49.3
Average	21.3	20.7	23.7	23.3	20.0	19.3	21.4
Smooth Brome							
Fall 1963	58	59	51	54	55	33	51.7
Spring 1964	18	24	22	23	16	6	18.2
Summer 1964	9	16	14	14	10	4	11.2
Average	28.3	33.0	29.0	30.3	27.0	14.3	27.0
Delmar Wheat							
Fall 1963	94	93	96	91	93	92	93.2
Spring 1964	71	76	72	78	76	77	75.0
Summer 1964	41	46	44	59	66	65	53.5
Average	68.7	71.7	70.7	76.0	78.3	78.0	73.9
Grand Average	38.1	43.4	41.4	43.0	39.7	35.0	40.1

[1] October 25, 1963
[2] April 13, 1964
[3] August 5, 1964

not greatly reduce stands. As shown in Table 6, the average number of infected seeds in the spring of 1964 was moderately high on untreated seed and also where seed was planted in soil that had been treated with 40% HCB. Table 6 also shows that some infected seeds were found where seeds had been treated with Arasan, Captan, and Semesan. Some infected seeds were found where the soil had been treated with Terraclor. At the northern Utah study area, Arasan treated seeds had only .4 of an infected seed per 500 seeds examined. Captan had 1.6 infected seed per 500 seeds examined, but Semesan had 18.6 infected seeds per 500 seeds examined. The Terraclor soil treatment also reduced the number of infected seeds compared with the untreated seed lots and the HCB soil treatment.

At the central Utah study area, climatic conditions were not favorable for rapid seed germination. On October 29, 1963, seedlings had not started to emerge, but some of the seeds were removed from the soil and examined. On this date, wheat was germinating rapidly and some crested wheatgrass, intermediate wheatgrass and a few smooth brome seeds had just started to germinate. Table 7 shows that seed treatment with Arasan, Captan, and Semesan resulted in an increased emergence and survival for crested wheatgrass, intermediate wheatgrass and smooth brome (Figure 5). However, seed treatment with these fungicides had little or no effect in increasing stands of slender wheatgrass or wheat (Figure 6). The soil treatment with Terraclor reduced seedling emergence for crested wheatgrass, intermediate wheatgrass and smooth brome. Soil treatment with HCB resulted in a slight decrease in emergence for all

Table 6 . Percentage of seeds of five species planted at Green Canyon that were infected by Fodosporiella verticillata when removed from the soil and after 21 days where seed or soil had received various fungicide treatments.

Crested wheatgrass	Untreated		Arasan 75		Captan 75		Semesan		HCB (40%)		Terraclor	
	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.
1	47	48	0	0	0	0	5	8	43	43	2	2
2	22	24	1	1	2	2	13	13	16	23	5	6
3	55	59	0	0	0	1	2	4	34	38	2	3
4	13	16	0	0	1	1	3	3	7	8	1	1
5	9	10	0	0	0	0	0	0	22	23	2	2
Average	29.2	31.4	.2	.2	.6	.8	6.6	5.6	24.4	27.0	2.3	2.8
Intermediate wheatgrass												
1	58	58	0	0	0	0	4	8	31	38	0	1
2	22	24	0	0	0	0	6	6	65	69	0	1
3	38	40	0	1	0	0	1	1	25	32	0	0
4	13	22	0	0	2	3	6	6	20	21	2	2
5	10	11	1	1	1	1	0	0	18	18	1	1
Average	28.2	31.0	.2	.4	.6	.8	3.4	2.6	31.8	35.6	.6	1.0
Slender wheatgrass												
1	0	4	0	0	0	0	0	0	0	0	0	0
2	2	3	0	0	1	1	0	1	1	1	0	0
3	6	7	0	1	0	0	1	4	5	8	1	1
4	6	6	0	0	1	1	2	3	17	17	1	1
5	1	1	0	0	0	0	3	3	4	4	2	2
Average	3.0	4.2	0	.2	.4	.4	1.2	2.2	5.4	6.0	.8	.8

Table 6 . --(continued)

		Untreated		Arasan 75		Captan 75		Semesan		HCB (40%)		Terraclor	
Smooth brome		Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.
	1	58	60	0	0	0	1	12	19	74	76	3	6
	2	55	56	0	0	0	1	6	7	70	70	3	4
	3	59	63	0	0	0	6	2	2	66	68	11	12
	4	33	35	0	0	0	0	4	5	17	19	2	2
	5	25	25	0	0	0	0	5	5	54	54	3	3
	Average	46.4	47.8	0	0	0	1.6	1.8	7.6	56.2	57.4	4.4	5.4
Delmar wheat													
	1	13	14	0	0	0	0	4	4	7	14	0	1
	2	18	18	0	0	0	0	17	17	41	43	0	0
	3	33	33	0	0	0	0	1	1	30	30	7	7
	4	13	21	0	0	0	0	0	0	11	13	1	1
	5	2	2	0	0	0	0	6	6	17	21	1	1
	Average	15.8	17.6	0	0	0	0	5.6	5.6	21.3	24.2	1.8	2.0
	Grand Total	112.6	132.0	.4	.8	1.6	3.6	18.6	23.6	139.0	150.2	10.0	12.0

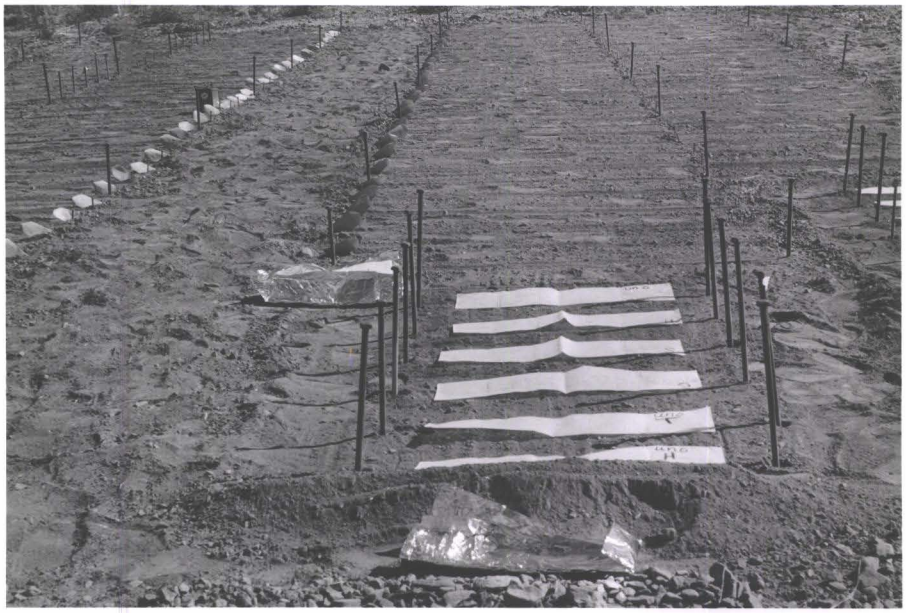
Table 7. Emergence from treated seed in the fall of 1963 and number of living plants in the spring and summer of 1964 in central Utah.

Date	Untreated	Arasan	Captan	Semesan	HCB	Terraclor	Average
			Fungicide				
Crested Wheatgrass							
Fall 1963[1/]	0	0	0	0	0	0	0.0
Spring 1964[2/]	13	47	45	49	22	7	30.5
Summer 1964[3/]	5	30	26	32	6	1	16.7
Average	6.0	25.7	23.7	27.0	9.3	2.7	15.7
Intermediate Wheatgrass							
Fall 1963	0	0	0	0	0	0	0.0
Spring 1964	16	55	54	49	44	8	37.7
Summer 1964	7	46	43	42	30	2	28.3
Average	7.7	33.7	32.3	30.3	24.7	3.3	22.0
Slender Wheatgrass							
Fall 1963	0	0	0	0	0	0	0.0
Spring 1964	13	13	15	16	16	14	14.5
Summer 1964	49	49	45	47	60	18	44.7
Average	20.7	20.7	20.0	21.0	25.3	10.7	19.7
Smooth Brome							
Fall 1963	0	0	0	0	0	0	0.0
Spring 1964	4	22	23	23	16	2	15.0
Summer 1964	1	10	8	5	1	0	4.2
Average	1.7	10.7	10.3	9.3	5.7	0.7	6.4
Delmar Wheat							
Fall 1963	0	0	0	0	0	0	0.0
Spring 1964	57	71	73	59	60	64	64.0
Summer 1964	51	62	61	53	53	51	55.2
Average	36.0	44.3	44.7	37.3	37.7	38.3	39.7
Grand Average	14.4	27.0	26.2	25.0	20.5	11.1	20.7

[1/] October 29, 1963

[2/] April 16, 1964

[3/] July 22, 1964



Figures 5 and 6. The untreated rows of smooth brome and crested wheatgrass in central Utah contained very few plants compared with rows treated with Arasan, Captan or Semesan. Although Podosporiella infected wheat seeds, stands from untreated seed were similar to stands from treated seed.

species except slender wheatgrass and wheat.

The number of infected seeds in the nylon sleeves that were removed from the central Utah site in the spring of 1964 show a high infection of susceptible species for the untreated seed and also the seeds planted where the soil had been treated with HCB (Table 8). Number of infected seeds was relatively high for seeds of crested wheatgrass, intermediate wheatgrass, and smooth brome treated with Captan. This study has shown that seed treatment with Arasan 75, Captan 75 and Semesan at rates recommended by the manufactures of the respective fungicides are not adequate for complete control of Podosporiella when fall plantings are made.

Table 8. Percentage of seeds of five species planted at Ephraim that were infected by Podosporiella verticillata when removed from the soil and after 21 days where seed or soil had received various fungicide treatments.

	Untreated		Arasan 75		Captan 75		Semesan		HCB (40%)		Terraclor	
Crested wheatgrass	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.
1	76	82	3	4	13	25	1	8	30	44	0	0
2	36	48	3	6	20	36	3	5	71	76	0	0
3	52	57	4	5	46	48	6	10	52	56	0	0
4	60	64	9	9	8	8	2	2	36	40	0	0
5	73	77	6	6	32	32	5	5	49	51	0	0
Average	59.4	65.6	5.0	6.0	23.8	29.8	3.4	6.0	47.6	53.4	0	0
Intermediate wheatgrass												
1	84	84	3	5	4	13	0	2	37	47	0	0
2	68	75	1	4	8	21	1	2	51	57	0	1
3	66	68	6	7	36	36	0	3	46	49	0	0
4	34	36	5	5	10	10	1	1	58	59	0	0
5	80	84	1	2	27	27	1	1	50	52	0	0
Average	66.4	69.4	3.2	4.6	16.4	21.4	.6	1.8	48.4	52.8	0	.2
Slender wheatgrass												
1	3	6	0	1	3	4	1	1	1	1	0	0
2	6	12	1	1	2	2	1	4	5	5	0	0
3	2	5	1	3	3	3	2	2	0	0	0	0
4	0	1	3	3	1	1	3	3	14	14	0	0
5	35	43	2	2	3	3	7	7	2	2	0	0
Average	9.2	13.4	1.4	2.0	2.4	2.6	2.8	3.4	4.4	4.4	0	0

Table 8 . --(continued)

		Untreated		Arasan 75		Captan 75		Semesan		NCB (40%)		Terraclor	
Smooth brome		Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.	Rem.	21d.
	1	92	97	1	8	17	30	4	13	49	69	0	0
	2	70	85	2	7	22	50	7	9	83	88	0	3
	3	84	91	2	5	39	57	7	7	72	76	0	2
	4	92	93	9	10	19	30	4	4	84	85	0	1
	5	91	93	8	9	42	42	6	10	82	84	0	0
	Average	85.8	91.8	4.4	7.8	27.8	41.8	6.0	8.6	74.0	80.4	0	1.2
Delmar wheat													
	1	26	37	0	2	0	0	0	1	6	14	0	0
	2	15	32	0	0	0	0	0	0	7	13	0	1
	3	35	40	1	1	1	1	0	0	7	8	1	1
	4	23	25	2	2	3	3	0	0	8	29	2	3
	5	29	29	3	3	3	3	1	2	7	10	0	0
	Average	25.6	32.6	1.2	1.6	1.4	1.4	.2	.6	7.0	14.8	.6	1.0
	Grand Total	246.4	272.8	15.2	22.0	71.8	97.0	13.0	20.4	181.4	205.8	.6	2.4

XII-A. Seed germination, seedling emergence, and plant survival at high elevations in Central Utah.

Thirty-six, 45 and 67 species or strains of grasses and forbs were planted at two high elevation sites in 1958, 1959 and 1960. Each species was planted in rows to follow seedling emergence and seedling mortality. The same species and strains were also planted in nylon sleeves which were removed at selected dates in the fall, winter and spring to follow seed germination. Areas used for the germination studies were staked with long poles so that samples could be located after deep snow covered the ground. All studies at each location were adjoining so that differences due to locations would be minimized.

The two areas in Ephraim Canyon are less than 2 miles apart, but slope and exposure are quite different: (1) Philadelphia Flat is located on a wide, near level terrace at an elevation of approximately 10,000 feet. This area is frequently covered with snow from late October or early November until the air temperature is relatively high the following May or early June, when frost danger is low. This area is subjected to flooding during rapid snowmelt in the spring. Flooding has also caused a breakdown in the soil structure, which in turn has decreased soil aeration, reduced water holding capacity, and favored crusting. (2) Summit Enclosure is on a west facing slope of approximately 8 percent at an elevation of 10,200 feet. Snow depth, during the winter period, is usually less than on Philadelphia Flat due to increased melting in the fall and spring, and wind action. Soil may be frozen during the winter. When the soil has been bare or snow covering has been shallow,

alternate freezing and thawing has produced heaving, frost damage, or rapid drying of the surface soil around the seeds. Flooding has been observed, but does not appear to be a serious problem on this site.

Seeds used were freshly harvested except that older seed lots of intermediate wheatgrass, slender wheatgrass, mountain brome and smooth brome were also included in this study. Where practical, seeds were harvested from high elevation areas similar to the study sites.

Laboratory germination tests at 68 and 82°F. were made on all seed lots in the fall of each year and again after seeds were about one year old. These seeds were treated with Captan 75, according to directions, prior to placement in the germinator since mold had developed on seeds of many species in earlier tests. Tests were made to determine the difference in seed germination soon after harvest and germination after dry storage for about one year. Laboratory seed germination tests were also used as a control for the seeds planted in nylon strips and the field emergence studies.

This study has been divided into three phases. In one phase, the germination of seeds in nylon bags, planted under snow or soil, on two dates of planting was checked at intervals during the winter and spring. In the second phase, seed of each species was planted in rows in the fall, and emergence and mortality counts were made at intervals during the following spring and summer. In the third phase, plant establishment and plant survival have been recorded each year.

One hundred seeds of a single species were placed in pockets in nylon strips and the pockets were closed and stitched. Large seeds were placed

in nylon with a mesh opening about 1/20-inch square. Species with small seeds were placed in bags from light weight nylon material with a fine mesh.

Early fall plantings of seeds in nylon strips were made under 3/4-inch of soil in September at both Summit and Philadelphia Flat. Plantings were also made after the area was covered with snow. Part of these strips were placed on the soil surface and part were placed at a depth of 3/4-inch below the soil surface. The original snow cover was replaced after planting.

One series of bags planted in the early fall was removed from each area when the second (late) planting was made to determine seed germination in the fall. Subsequent removal of seed from Philadelphia Flat and Summit was made during the winter just before the snow melted in the spring, and just as the soil was drying in the early summer.

In the second phase of this study, seedling emergence and seedling mortality was followed during the summer. Fall plantings with 100 seeds of each species replicated three times were made in mid September. All species were planted at random, except that older seed lots and freshly harvested lots of intermediate wheatgrass, smooth brome, slender wheatgrass and mountain brome were planted in adjoining rows. Each row was 5 feet long. Large seeds were planted at a maximum depth of 2 cm and small seeds were planted at a maximum depth of 1 cm. Spring plantings were also made at Philadelphia Flat in June 1961. This spring planting differed from the fall plantings in that 50 seeds were planted in rows 30 inches long.

Seedling emergence and seedling mortality counts were made on each area just after snowmelt and at intervals of about 1 week. On each date the newly emerged seedlings were marked with color-coded toothpicks. Average seedling emergence for each species during the first year and subsequent germination during the second spring are shown in previous progress reports.

Emergence from spring planted native forbs and grasses with a high seed dormancy was usually very low. As expected, the domestic grasses, such as intermediate wheatgrass, produced good stands from spring plantings when soil moisture was adequate for seed germination.

In contrast, very few of the domestic grasses produced seedlings in the second years from "holdover" seed. Natives producing the most seedlings in the second year from holdover seed were: Bromus carinatus, Agropyron trachycaulum, Delphinium nelsonii, Erythornium grandiflorum, Lomatium nuttallii, Osmorhiza occidentalis, Penstemon rydbergii, Stellaria jamesiana, Valeriana edulis, and Viola nuttallii. Annual species such as Collomia, Madia, and Polygonium usually produced abundant plants in the second growing season from seed produced the first growing season.

In general, the grasses produced better stands than the forbs. Additional mortality had usually occurred when counts were made in the second and third growing seasons, but death loss has usually been low after the second growing season. Some additional death loss occurred during the fall of 1963 and in the spring of 1964, but the number of surviving plants were very similar to the numbers surviving in 1963.

Most of the additional death loss observed was attributed to pocket gophers. Gophers severed the roots by tunneling under the plants, ate the crowns, or covered the plants with mounds of soil. Most of this damage occurred during the winter period when the soil was covered with snow (Figures 7 and 8). In general, mortality of grass plants was less than for the forbs.

This study has shown that conditions necessary for seed germination vary with species. Seeds of some of the domestic grasses, crested wheatgrass, intermediate wheatgrass, and smooth brome in particular, began to germinate as soon as moisture was adequate even though temperatures around the seed often went below freezing at night. Seeds of some native and introduced grasses and forbs were slower to begin germinating under the low night temperatures and limited moisture. Typical of these species were Alopecurus, orchardgrass, Geranium, and lupine. Seed germination in many other native plants remained low until seed dormancy was broken up by cold moist conditions existing in the unfrozen soil under the deep snow. Typical of these plants were mountain brome, slender wheatgrass, native Stipa, and tarweed. Seeds of another group did not germinate in the fall or winter while the soil was cool, but germinated after the soil warmed up in the spring, or germinated readily at 68 to 82°F. in the laboratory. Typical of this latter group were Aquilegia and Potentilla.

Germination, emergence and survival of the annuals, cluster tarweed, douglas knotweed and collinsia were high in each planting. These annuals produced good seed. The seeds were allowed to produce dense seedling stands during the second year before they were eradicated.

Figures 7 and 8. Most of the damage to seeded plants occurred under the winter snow. Gophers severed the roots by tunneling under the plants, ate the crowns, or the plants were covered and damaged by soil mounts and winter casts.

Average grass seedling emergence per 100 seeds planted in 1958, 1959 and 1960 was 27.2, 23.8, and 32.0 but living plants remaining in 1964 were only 5.3, 7.3, and 7.9, respectively. Average perennial forb seedling emergence per 100 seeds planted in the three years was 8.4, 13.1, and 22.1. Average survival per 100 seeds of these perennial forbs in the summer of 1964 was only 2.2, 3.1, and 5.2, respectively. Four relatively undesirable increasers, toungeleaf violet, low larkspur, springbeauty and fawnlily, made up over 49 percent of the living forbs.

III-8 Revegetation trials on mountain ranges.

Intermediate and high elevation ranges are usually important to the Intermountain Region both as a watershed and for forage production. On many ranges that have been depleted, the vegetative cover is not adequate to protect the soil. Much of the topsoil on heavily grazed ranges at high elevations has been lost by erosion. Stock enclosures established on representative areas 20 to 50 years ago have shown little or no improvement through natural revegetation. The low fertility and reduced moisture holding capacity of the soil in the remaining subsoil may be a factor in plant establishment, production of forage, and erosion control.

However, good grass stands have been obtained by selected species, planted by recommended methods. Drilling with a standard drill, broadcasting and harrowing, or broadcasting on freshly plowed ground has usually given good results. Planting in furrows (deep or semi-deep) has usually given the best results.

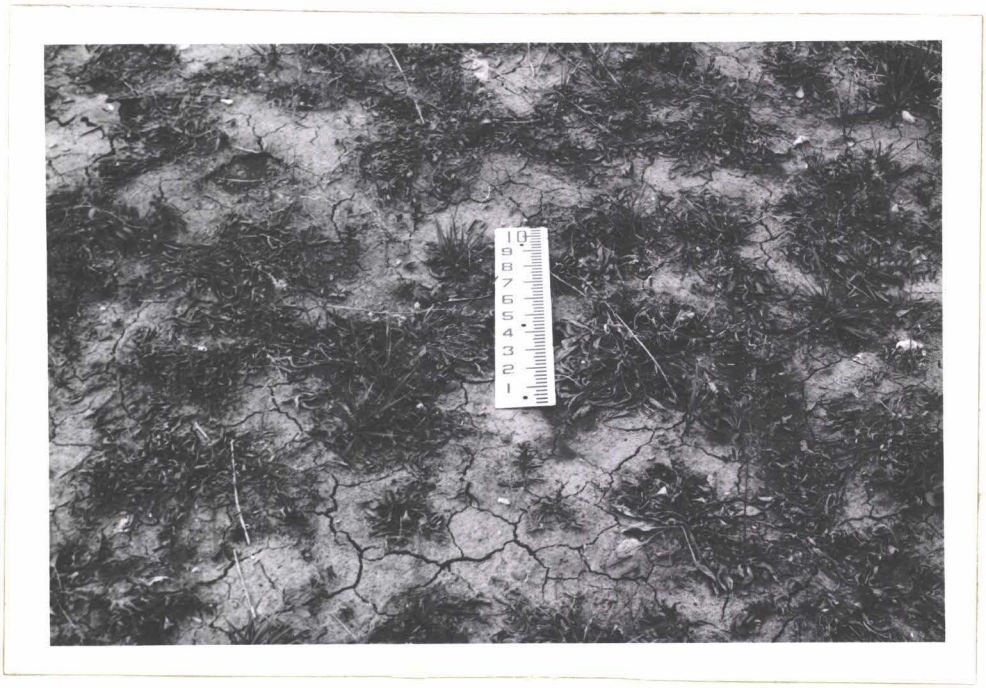
Reduction of competing vegetation has usually been necessary. Annuals and ephemeralds have usually increased when the better forage plants have been weakened or killed. Control or eradication of these plants has usually been difficult and repeated failures have occurred on some areas that have been invaded by these plants.

Springbeauties, larkspur, violets and similar ephemerald species grow rapidly, flower, mature seed, and largely disappear by midsummer. Forage production by these plants is usually low and plant cover remaining

in the late summer and fall after these plants have dried is low (Figures 9 and 10). Many annuals such as Collomia frequently produce seed by midsummer, dry, and provide very little forage. Other annuals such as the tarweed usually germinate and begin to grow before the snow melts in the spring, but usually continue to grow as long as moisture is available.

Studies have shown that selected species will do well on some dry, badly eroded steep slopes once they become established. Limited plant establishment has been obtained from direct seeding on these sites, but establishment is usually slow and uncertain. As an example, on the subalpine plots at Bear Creek good seedling stands were obtained but plant establishment was slow. The stands obtained have not provided the soil protection required to arrest or retard soil erosion. Although stands have improved, fertilizer is needed on this site. Where the plant cover protected the soil from active erosion, relatively rapid soil build-up occurred by soil deposition from surrounding areas and accumulation of organic matter.

Soil and snow temperatures at or near the soil surface under a snow cover of one or more feet are usually around 30 to 34°F. Seed development and other physiological changes at these temperatures may determine the seedling stands produced. Freezing and thawing of the soil due to diurnal fluctuations in temperature may produce frost damage and heaving. Other factors which may influence production of seedling stands are competition for moisture, micro-organisms in the soil, insects, rodents, and climatic conditions.



Figures 9 and 10. Ephemeralds grow rapidly in the spring, but largely disappear and provide little forage or soil protection after the plants have dried.

The rhizomatous grasses have usually been superior to the bunchgrasses because they spread vegetatively and are long-lived. Seedlings of the rhizomatous grasses: Kentucky bluegrass, quackgrass, and smooth brome made in 1917 by Dr. A. W. Sampson, are still present and largely controlling soil erosion although heavy grazing has been the practice. Short-lived plants such as slender wheatgrass and mountain brome have produced good stands but these stands usually deteriorate and perish. Unless these short-lived plants are replaced through natural revegetation, the soil is left bare.

At high elevations, smooth brome is one of the best species (Figures 11 and 12). Good stands have also been produced with many other species including tall oatgrass, slender wheatgrass, mountain brome, timothy, orchardgrass, intermediate wheatgrass, Kentucky bluegrass, and quackgrass.

Rhizome plantings have proven to be a dependable method for obtaining stands on small critical areas. Transplanting can be done in the spring, summer, or fall when the soil moisture is adequate for establishment. Spring and summer plantings have been superior to late fall planting on areas where severe frost heaving has occurred in the late fall and early spring. While vegetative propogation will have limited application, it may be necessary to restore the vegetative cover on many critical areas where seed plantings have been unsuccessful.

Figures 11 and 12. At high elevations smooth brome is one of the best species. This rhizomatous grass can be established by seeding or by vegetative propogation.

III-C. Vegetative growth of some cool season plants as affected by moisture and temperature.

Plant growth periods are largely determined by available moisture, soil temperature, air temperature, snow depth, and other climatic conditions. The annual growth and "dormancy" of cool season perennial grasses and forbs is cyclic in nature. In the Intermountain Region most plant growth is made during the spring and early summer months. With many plants secondary herbage growth is made during the fall months when the summer foliage is drying or if the soil moisture has been depleted with the replenishment of favorable soil moisture. Part or all of this secondary growth may persist throughout the winter and active early spring growth may begin under a deep snow cover.

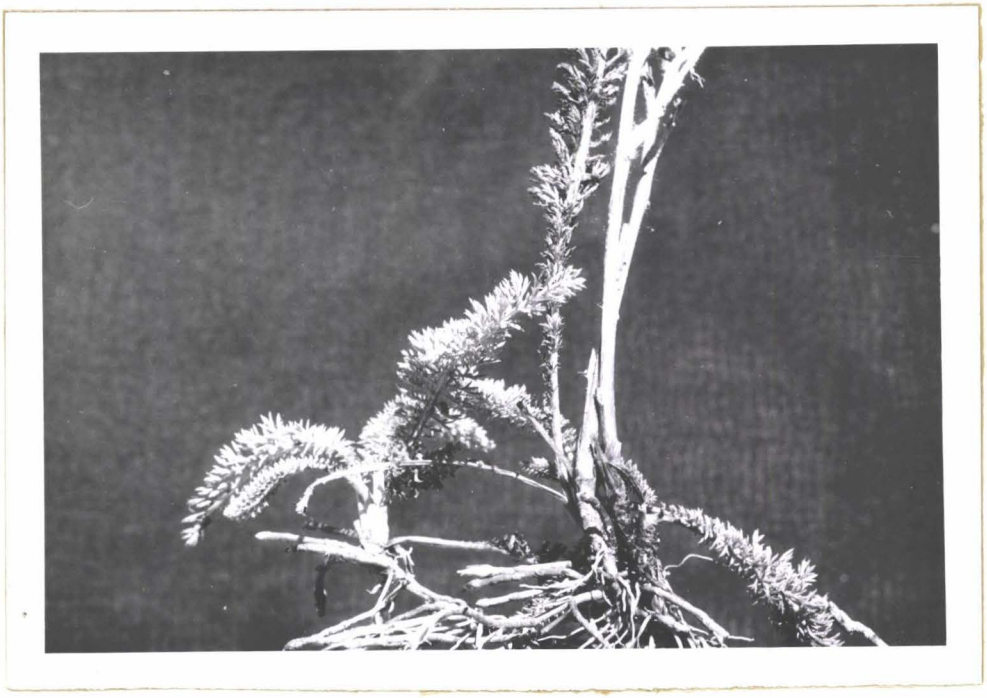
Plants producing bulos, tubers, or corms produced roots and started to grow in the fall. When the soil under the snow was frozen, little or no growth took place during the months of December, January and February. However, even when the soil below the snow was frozen to a depth of several inches in the late fall and winter months, the soil thawed in late February or March. When the soil thawed, shoots and rhizomes began to elongate and often pushed into the snow. Some plants of springbeauty protruded into the snow over 3 inches and some trout-lily plants protruded up into the snow more than 5 inches. Low larkspur plants also emerged from the soil surface under a deep snow cover and frequently protruded into the snow mantle.

Forbs such as Richardson geranium, niggerhead, edible valerian and lupine formed new buds in the crown during the fall which persisted

and elongated under the snow (Figure 13). These buds were usually protected by old growth, soil or organic material. The tips of some plants were exposed and outer bracts were leaflike and green. Rhizomatous forbs: yarrow, Rydberg penstemon, sweetsage, and aster produced rhizomes or shoots in the fall but the terminal buds usually remained at or just below the soil surface until the snow melted the following spring. Still other forbs such as tinpiute gilia, Arabis, and Thalespi produced green basal leaves that persisted throughout the winter months.

Bunch grasses: crested wheatgrass, orchardgrass, tall oatgrass, slender wheatgrass, mountain brome, and similar grasses produced abundant basal leaves when conditions were especially favorable in the fall (Figure 15). Leaves over 5 inches long have been measured just after the permanent winter snow covered the ground. However, when fall temperatures were low or moisture was restrictive, secondary growth was limited to production of shoots protected by old growth, soil or organic material. Additional growth has been measured while the soil is covered with snow. Mountain brome plants staked in the fall had grown from 11 mm. to 25 mm. during the period snow covered the ground. Most of this growth under snow occurred after the soils began to warm in late February or March. Staked slender wheatgrass plants increased from 7 mm. to 14 mm. during the period the permanent winter snow covered the soil and plants.

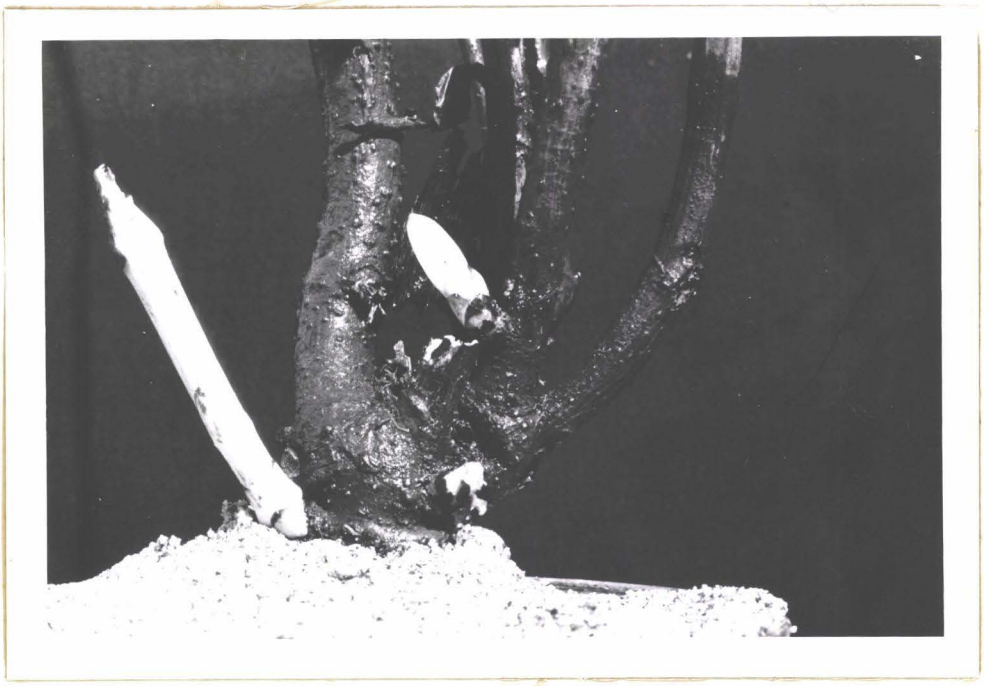
Sodgrasses: smooth brome, reed canary, and intermediate wheatgrass produced rhizomes which emerged and produced new shoots when conditions were favorable in the fall, but when temperatures were low



Figures 13 and 14. The lupine in the upper photo produced buds in the fall which began to elongate in the spring prior to spring snowmelt. The rhizomatous yarrow developed rhizomes in the fall. Some elongation was observed under the snow, but the terminal buds were usually found at or just below the soil surface.

and soil was frozen, the terminal buds remained just below the soil surface until the soil thawed in the spring. Smooth brome shoots over 3 inches long were observed protruding into the snow when the snow depth was still 68 inches.

Most of the native shrubs developed latent buds in the fall and only limited growth or enlargement was observed until the following spring. However, new shoots from below and above the soil surface were observed in the fall on some red elderberry (Figure 16).



Figures 15 and 16. Mountain brome and most of the other perennial bunchgrasses produced abundant basal leaves in the fall. Many of these leaves began to elongate under a deep winter snow. Red elderberry developed new shoots in the fall.

III-D. Uniform study for seeding depleted sites on western ranges.

Plans to establish a uniform study were first made at the Range Society Meetings held at Great Falls in January 1957. This study was conducted at six locations, as follows: Bozeman, Montana; Ephraim, Utah; La Grande, Oregon; Logan, Utah; Pullman, Washington; and Reno, Nevada. A general plan of study was made from the composite suggestions by Dr. Keller and the field men located at the above areas. A. C. Hull acted as coordinator, and assembled this material into a study plan form.

The first plantings were made on one area at each location according to plan in the fall of 1957, and spring of 1958. Subsequent plantings at this site were made in the fall of 1958, spring and fall of 1959, and in the fall of 1960. Additional spring plantings were made after the snow melted in 1961. Previous progress reports contain data collected prior to 1964.

Plantings were made on Forest Service land within two enclosures constructed by the Forest Service for this study. The two areas are only about two miles apart, but slope and exposure are quite different:
(1) Philadelphia Flat - is located on a wide near level terrace at an elevation of approximately 10,000 feet. This area is frequently snow covered from the first heavy snow in October or November until the air temperature is relatively high the following May or early June when frost danger is low. When dry or unfrozen soil is covered by snow in the fall, the soil may remain at or above freezing throughout the winter. This area is subjected to flooding during rapid snowmelt in the spring. Flooding may also cause a breakdown in the soil structure which in turn may decrease

soil aeration, reduce water holding capacity, and favor crusting.

(2) Summit Enclosure - is on a west facing slope of approximately 8 percent at an elevation of 10,200 feet. Snow depth during the winter period on this area is usually less than on Philadelphia Flat due to increased melting in the fall and spring and wind action. Soil may be frozen during the winter. When the soil is bare or snow covering is shallow, alternate freezing and thawing may produce heaving, frost damage, or rapid drying of the surface soil around the seeds. Flooding has been observed but does not appear to be a serious problem on this site.

Major treatments included nine seedbed treatments applied on the contour and five fertilizer treatments applied up and down the slope at right angles to seedbed treatments. Seedbed treatments and fertilizer applied in each of the four years are listed below.

A. Seedbed treatment	1st Year 1957-1958	2nd Year 1958-1959	3rd Year 1959-1960	4th Year 1960-1961
1. Plow fall - summer fallow - plant next fall	X	X	X	
2. Plow fall - preparatory crop in fall - plant next fall	X	X	X	
3. Plow fall - plant in fall	X	X	X	X
4. Valley soil - plant in fall	X	X	X	X
5. Plow fall - plant in fall - 1/2-inch sawdust	X	X	X	X
6. Plow fall - transplants	X	X	X	X
7. Plow fall - 4 inch contour furrows - plant in fall	X	X	X	X
8. Plow fall - plant spring	X	X	X	X

Seedbed treatment (continued)

A. Seedbed treatment	1st Year 1957-1958	2nd Year 1958-1959	3rd Year 1959-1960	4th Year 1960-1961
9. Check - no seedbed preparation or treatment	X	X	X	X
10. Plant fall - spray 4 lbs. 2, 4-D in spring	X	X	X	
11. Spray 4 lbs. 2, 4-D in spring - plant in fall	X	X	X	
12. Spray 4 lbs. 2, 4-D in spring - plant in spring			X	
13. Plow fall - plant fall and cover seed with sand			X	X
B. Fertilizer treatment				
1. Nitrogen - 100# per acre N	X	X	X	
2. Phosphorus - 200# per acre P_2O_5	X	X	X	
3. Nitrogen plus phosphorus	X	X	X	
4. Nitrogen, phosphorus, potash and minor elements	X	X	X	X
5. Check	X	X	X	X

Percent soil moisture was determined at intervals throughout the growing season at both study areas. Soil and air temperatures during the growing season were recorded with a 7-day recording thermometer at the Summit Enclosure. A 31-day recording thermometer remained in operation throughout the year at Philadelphia Flat. At both locations, standard air temperatures and soil temperatures at 3/4-inch depths

were recorded. At the Summit area, additional temperatures were recorded at 6 inches above the soil surface and 1/4-inch below the soil surface. At Philadelphia Flat an additional temperature unit was located on the soil surface during the period that winter snow covered the area. This unit was placed in the soil at 1/4-inch depth during the spring, summer and fall.

Major species planted were native slender wheatgrass, native mountain brome, tall oatgrass, smooth brome and red fescue. Secondary species included meadow foxtail, orchardgrass, chewing fescue, intermediate wheatgrass and pubescent wheatgrass. In 1959 an artic Agropyron was substituted for the chewing fescue, Bromus tomentellus and intermediate wheatgrass was used instead of tall oatgrass and red fescue in major plantings made in the fall of 1960 and spring of 1961. Transplants of smooth brome were made each year. In the fall of 1960, transplants of Calamagrostis epigeios, reed canarygrass, Kentucky bluegrass, intermediate wheatgrass and pubescent wheatgrass in addition to smooth brome.

This study has demonstrated that success or failure of a seedling may be determined by one condition on one site and another condition on an adjacent area. In general, treatments that remove the native condition and provide some protection for adapted species have been satisfactory. Treatments that have been consistently best at Philadelphia Flat are valley soil, sawdust mulch, and contour furrows. At the Summit Enclosure sawdust mulch was consistently best and the spring drilling has been next best. Plant numbers were low on other treatments at the Summit Enclosure.

Fertilizers have not appeared to improve stand establishment or increase herbage production at either site. Sawdust mulches have usually improved stands at both locations but straw mulch has not appeared to be beneficial. Native slender wheatgrass and mountain brome consistently produced better seedling stands than the domestic grasses but these species are relatively short-lived. Fair to good stands of smooth brome, intermediate wheatgrass, pubescent wheatgrass, and artic wheatgrass have been obtained. The artic wheatgrass has spread vegetatively at the Summit areas. Smooth brome has increased vegetatively from direct seedlings and transplants. On old nearby studies smooth brome and similar long-lived grasses that spread vegetatively have been superior.